150 KV COCKCROFT-WALTON TYPE PARTICLE ACCELERATOR

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ABSTRACT. Details of the 150KV Cockcroft-Walton type particle accelerator, which has been constructed in this laboratory, are given. Use of radio-frequency ion-source, and 250KV isolation transformer for supplying voltage to the various circuits in the ion-source head, are its main features. A steady current of protons of more than 100 micro-amperes at the target has been obtained.

INTRODUCTION

A low voltage Cockcroft-Walton (C-W) type particle accelerator can be utilized excellently for the production of neutrons from the exothermic reactions viz., D (d, n) He^3 and D (t, n)He^4. This gives a cheap and copious source of monoenergetic neutrons of about 2.8 Mev and 14 Mev energy respectively from the two reactions. To start work in neutron reactions, we have constructed a C-W type accelerator in our laboratory, details of which are given below.

Figure 1 shows the block diagram of the C-W accelerator which is self explanatory.

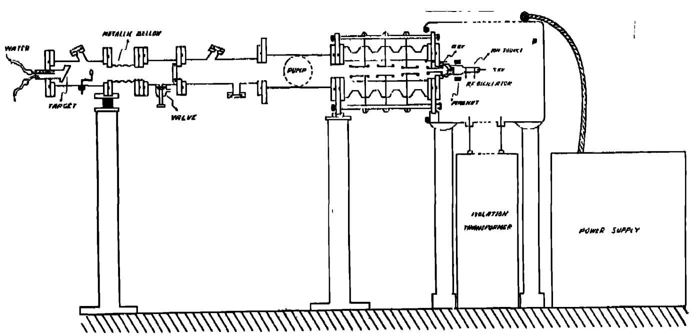

Fig. 1. Block diagram of the 150KV cockcroft-Walton type particle accelerator.

150KV POWER SUPPLY

For the generation of 150 KV, we have a Beta-electric company's power supply (Beta Electric Corp. New York, N.Y.) Model No. 2150-2R (2-5-1) which

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is based on a standard doubler circuit. Three transformers of 50KV each, in series, serve as the main high voltage transformers, and the two special X-ray tubes Eureka EV-3-75-T as the rectifier tubes. All the components of the high voltage power supply are placed inside a box 30″×30″×30″ filled with Burma Shell Diala-B oil. The high voltage can be varied from 0-150KV, with the help of a variac in the control panel, which is meant for operating the power supply from a distance.

Safety measures include the following ; (i) On over-voltage or over-load the high voltage is automatically removed, which can be put on again only if one starts from zero voltage. (2) Two inter-locks insure that no person can approach the high voltage side, without putting off the high voltage. (3) Spark-gaps inserted in the various points of the circuit, remove the momentary surges without damaging the main components. (4) When the high voltage is switched off, the high voltage point is automatically earthed.

ION SOURCE AND ASSOCIATED CIRCUITS

Our ion-source is essentially the same as that of Moak, Reese and Good (1951), the only difference being that the pyrex envelope of our ion-source is of a little bigger diameter than that of theirs. The ion-source base is connected through a palladium tube to a cylinder containing the gas to be used in the ion-source i e. dydrogen or deuterium. By controlling the temperature of the palladium tube, the flow of the gas to the ion-source is regulated,. A variable 24 volts A.C. transformer is used for this purpose. A 100MC oscillator of the same type as that of Moak, Reese and Good (1951) excites the discharge in the ion-source. A variable 1000 volts positive power supply provides the voltage to the oscillator. A variable positive voltage of 0-5000 volts is applied to the probe on the top of the ion-source to direct the positive ions towards the cathode. A coil of 2½″ internal diameter consisting of 1400 turns of no. 22 enamelled copper wire serves as the magnet. It serves the purpose of increasing the path length of electrons in the ion-source and hence intensifies the discharge. The current of this is supplied by a 50 volts 3 amperes power supply, using selenium rectifiers.

All the ion-source accessaries are placed inside an aluminium box 5′×3′×3′ with rounded exteriors. The output from the 150KV power supply is connected to the box through a special insulated cable. Since the whole box is at high voltage, it is essential to insulate the A.C. voltage supplied to the various circuits in the box. We have achieved this by a 2KW isolation transformer of 220 volts primary and 220 volts secondary with 250KV insulation between the primary and secondary. The isolation transformer placed in a container having nearly 80 gallons of Diala B oil is put just below the aluminium box. It was considered more advantageous to use this isolation transformer than the usual method of an A.C, generator in the box, driven by a motor below through an insulated belt etc. In our case, we are saved of the jerks to the box and the accelerating column.

ACCELERATING COLUMN

The accelerating column consists of alternate conducting and insulating sections. The insulating sections are porcelain cylinders each of 2½″ length, 6″ internal diameter and of 2″ thickness. The two ends of the cylinders are ground flat. The remaining surface is glazed to ensure absence of porousness. The conducting sections are steel plates with holes in the centre, placed between these insulating cylinders. The joints are made vacuum-tight by a special cement i.e. Epibond (obtainable from Furnace Plastics, Los Angeles, California, U.S.A.)

The final accelerating column consists of 4 sections with an over-all length of 11 inches. The two extreme faces of the column were further joined to two circular steel plates of 18″ diameter, with a hole of 5½″ diameter. Three perspex rods were fixed between these plates at the periphery to increase the mechanical strength of the accelerating column.

The metal plates carry cylindrical electrodes at their centre. These electrodes, which can be fitted from out-side, shape the electric field along the tube axis, so as to accelerate and focus the charged particles, At the same time they are designed to shield the tube walls from the stray ions.

150KV is distributed over a chain of resistors of 1200 Meg ohms. The tapping after every 300 Meg. ohms is connected to the cylindrical electrodes inside the accelerating column.

The positive ion beam from the ion-source is extracted by placing an electrode just below the ion-source hole to which a negative voltage with respect to the cathode of the ion-source is applied. The negative voltage can be varied from 0 to 15KV. This electrode also serves as the main focussing electrode.

INSULATION

The box with ion-source accessaries weighing about 500 lbs is supported by four perspex pillars which also serve the purpose of insulating the box from the ground. As these pillars were not commercially available, four perspex sheets (obtainable from ICI) were joined together by perspex screws and were turned on a lathe to get circular pillars of 4″ diameter. Though the pillars are of 4 feet height, the nearest distance of the box from the electrical ground is one foot.

VACUUM SYSTEM

The vacuum in the whole system is maintained by an MCF-700 oil diffusion pump of capacity 650 lit/sec. with a backing Duo-Seal mechanical pump of capacity 380 lit/min. A freon gas cold trap just above the diffusion pump is used to cool the oil vapours. Pressure of the order of 10^{-6} mm of mercury is maintained in the whole system. Even when satisfactory vacuum-tightness has been obtained, a high pumping speed has to be maintained, as the ions admitted for acceleration are always accompanied by neutral gas which would build up a pressure. An NRC type 501 thermocouple gauge and a 507 ionization gauge are included in the system just above the cold trap to measure the pressure.

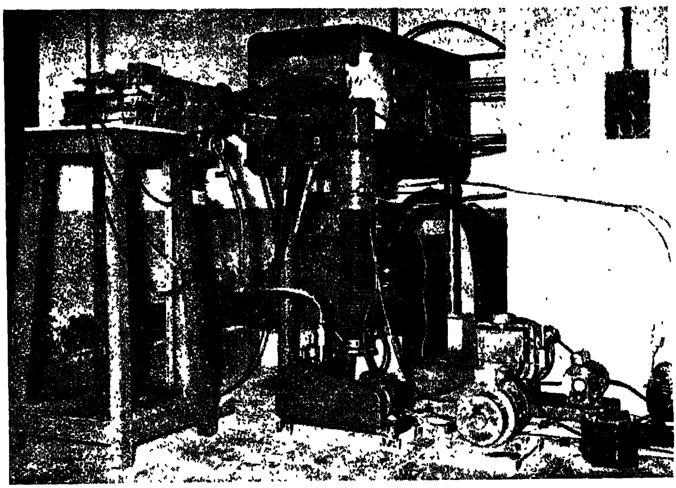

Fig. 2. A photograph of the 150KV Cockcroft-Walton type particle accelerator.

The various parts in the vacuum system after the accelerating column are (i) A 'T'-shaped copper tubing which connects the diffusion pump to the main vacuum system side. (2) A metallic system containing a vacuum-tight valve which by manual operation from out-side can separate the system on the acceleration column side from the target side. This portion also contains a second valve to let in air or pump the target side when necessary. (3) A metallic bellow to adjust target to bring the beam in the centre. (4) The target end which includes a quartz piece and a side window in front of the quartz to see the flourescence pattern of the beam when it falls on the quartz. The actual target is put on the end of this piece.

Whenever A.C. mains supply fails or at night when no body is attending the accelerator, a convertor run on the D.C. battery set, available in the laboratory, is used to keep the mechanical pump running. Also included in the diffusion pump heater-circuit is an automatic swith, so that if the water supply to the diffusion pump fails, the heater voltage should go off.

CONTROL ROOM

The voltage of the various power supplies inside the box containing ion-source accessaries are varied from the control room with the help of perspex rods. These rods are fixed to the variacs in the input of the power supplies on one side, and to the control knobs in the control room on the other side. By rotating these rods from the control room, the variacs can be adjusted to give the desired voltages in the power supplies. The control room also contains (1) : Control panel for 150KV power supply. (2) Ionization guage circuit to measure vacuum in the system. (3) Beam current integrator etc. (4) A telescope to read the various meters in the box, through a hole in the wall of the control room. (5) Detecting equipment.

OPERATION

The accelerator has been in operation for the last many months, using a proton beam. Beam current of protons of more than 100 micro-amperes has been obtained on the target, about 5 feet away from the ion-source. Beam can be kept steady continuously for many hours. No insulation breakdown troubles have been encountered.

ACKNOWLEDGMENTS

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REFERENCE

Moak, C. D., Reese, H. Jr., and Good, W. M., 1951, Nucleonics, 9, 3, 18.